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TITLE

MICROSCOPIC OBSERVATIONS OF THE DEVELOPMENT OF THE MALE
AND FEMALE SCALE INSECT (NUCULASPIS CALIFORNICA (COLEMAN).)

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AND FEMALE SCALE INSECT (NUCULASPIIS CALIFORNICA (COLEMAN).)

There are four distinct periods of development of the scale insect that can be observed with ordinary microscopic examination and without any special preparation of the scale insect. The microscope used for this work has a 2 1/2 X and 4 X ocular lenses and 3 X, 4 X, 5 X objective lenses. The best lens combination found by this observer was the 4 X ocular lens with the 4 X objective lens. This lens combination has a depth of field slightly greater than the thickness of the scale insect and thus the entire insect was in focus for detailed observation. The 4 X ocular lens and 5 X objective lens was used for some minute observation of some features of the adult male and female scale insects.

The terminology employed by Ferris ^{1/} in his description of the genus Nuculaspis and the species Nuculaspis californica (Coleman) will be used to designate that portion of the insect under observation. In describing the immature adults and the mature adult female the word prosoma refers to the head parts and the first and second thoracic segments. The postsoma refers to the third thoracic segment and the abdominal segments. In the mature adult male the head, thorax, and abdomen are quite distinct and so in description of the adult male normal terminology will be employed.

THE EGG AND CRAWLER STAGE

From observations of the emergence of the 1950 population of scale insects in the vicinity of Spokane, Washington it appears that the reproduction habits of Nuculaspis californica are ovoviviparous. I have found eggs outside the body of the female in several instances but this seems to be the exception rather than the rule and may be due to squeezing of the female when the needle was extracted from the twig.

In the Spokane area approximately five weeks elapsed between the emergence of the winged male scale and the appearance of embryonic eggs within the body of the female scale insect. About two weeks after the eggs were first noticed live crawlers were found beneath the scale cap. Many scales had no crawlers beneath them and in these instances no eggs outside the female body were found.

^{1/} Ferris, G. F. Atlas of the scale insects of North America, Series II, Numbers SII - 250 (genus Nuculaspis, new) and SII - 251 (Nuculaspis californica (Coleman), new species). Stanford University Press, Stanford University, California, November, 1938.

The eggs are about 0.1 millimeter long, typically egg-shaped and have a very slight greenish or greenish yellow cast. The crawlers are hatched ovoviviparously over a period of several weeks. On samples examined only four or five crawlers were seen under the scales and yet on puncturing the female body several eggs were seen. In two instances I uncovered scales in which the young crawler was only partially emerged. They apparently emerge head first for in each of these cases the antennae and legs could be seen while the abdomen was still within the female body.

The crawlers are somewhat egg-shaped when observed from above but appear quite flattened when seen laterally. They are yellowish tan in color and from 0.1 to 0.2 millimeter long. According to Ferris's description of the species all typical insect parts are present in this stage but only the legs and antennae are readily seen under low power magnification. From external observation of the legs there seems to be no difference in the structure of the pro-, meso-, and metalegs. The antennae are subfiliform stylate and are projected laterally from the head. Under low power the antennae seem almost horn-like.

The young crawlers move about for a short period. They may end up on any of the needles present. On the older needles it will be necessary to remove all the old scale cap for in many instances I have found the crawlers settling under these old scale caps. The young crawler inserts its stylet through a stomatal opening and then begins to form a scale cap which in the initial stages appears to be a white somewhat sticky, filamentous mass. The first instar occurs sometime after the crawler settles during which the legs and antennae are lost.

A white substance was found beneath the scale cap of the female that was not present until the crawler stage. A close examination of this apparent waste product leads me to believe that it is composed of old embryo casing and since they are of no apparent further use they have simply been eliminated by the female. The young crawlers may incorporate some of this substance into their scale for the two materials seem somewhat similar.

Since the reproduction habit is ovoviviparous, the crawler stage will probably last for several weeks. These insects appear most vulnerable for control during the crawler stage but what about those few that settle beneath the mother scale cap. The old scale cap would protect them until their own was formed.

The Adult Stage

The scale insect overwinters in the 2nd instar. The insect in this stage is from 1 to 2 millimeters long and a light reddish brown in color. The insect is soft bodied and no vestiges of legs, eyes, or antennae could be seen on uncleared specimens. The scale caps are a

dull black with the peak of the scale cap appearing as a greyish nipple. The fluid portion of the insect is very gelatinous in character. As the average daily temperatures become higher the body fluids become more liquid in nature and the insect changes from the reddish brown color to a golden tan. At this point the insect is still soft bodied and it is possible to see the pulsations of the insect as it extracts the plant juices. Once activity has started the insect undergoes a series of molts covering a period of about ten weeks with the only apparent change in the insect for the first eight weeks being in size.

At the end of eight weeks of development the insects are from 3 to 4 millimeters in length and about two millimeters thick. The insects are still soft bodied. During the latter two weeks the female develops a sclerotized plate on the upper portion of the postsoma. This plate is about one square millimeter in area and a reddish brown color. The male scales do not develop this sclerotized plate but tend to grow elongate during the latter two weeks period.

During the ninth week the males lose their mouth parts and develop legs, wings, and antenna. Four black ocelli-like structures appear on the mature male but examination by this observer failed to disclose the exact nature of these formations. One pair is just posteriorly and somewhat laterally of the antenna. The other pair is almost mandibular in location. The antenna is filiform with verticillate setae. The wings are attached to the mesothorax and a bar-like heavily sclerotized plate is present on the dorsal surface between the proximal ends of the wings. With the exception of this sclerotized plate, which is dark brown, the rest of the insect is golden tan in color. Parts of the thorax and the caudal end of the abdomen appear to be more heavily chitinated but generally speaking the male insect is soft bodied. The male insect is from 2 to 3 millimeters long when fully developed. At this time the scale cap apparently is built up in one direction only during the eight and ninth week for the nipple is about $\frac{1}{3}$ the distance from the end. The head is always found directly beneath the nipple. An elongated appendage at the caudal end of the abdomen evidently composes the genitalia. At the end of the ninth week nearly all the males had emerged from their scale caps.

There is little change in the female during the ninth week other than the appearance of a sclerotized plate on the dorsal portion of the postsoma and some growth. In several instances it was noted that the postsoma was projected from beneath the scale cap. On touching the insect with a needle point the postsoma was quickly retracted but a short while later it was again noticed projecting from beneath the scale cap. During the tenth and succeeding weeks the body of the female becomes heavily sclerotized with the exception of the postsoma. The postsoma retracts into the prosoma with the sclerotized plate forming a lid-like appearance over the indentation. The body color changes from golden tan to a very dark reddish tan as sclerotization takes place.

From examination of the position of the cast off skins of the female I am of the opinion that the female is able to rotate beneath her scale cap. This may account for the circular appearance of the female scale cap as compared to the elongate shape of the male scale cap.

The scale cap of the female is dull black with the nipple central. The outer fringe of the scale may be a greyish blue in color, somewhat translucent, and filamentos in nature. This fringe darkens and comes harder with age.

Protophasm that seemed like embryonic eggs was found within the body of the female three weeks after the emergence of the males.

A statistical analysis of the males and females taken during the eight and ninth week when sex was readily distinguishable revealed the following sex ratios: In natural ponderosa pine forests where there was less than one scale insect found per tree the sex ratio was approximately one male to three females. Under conditions where there were at least one scale insect per needle per tree the sex ratio was approximately one male to seven females.

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